Teo Sieu Zhien

Master of Science

2021

Ectoparasite Diversity and Infestation Rate on Rodents and Treeshrews in Different Habitats in Western Sarawak, Borneo

Teo Sieu Zhien

Institute of Biodiversity and Environmental Conservation
Universiti Malaysia Sarawak
2021

Ectoparasite Diversity and Infestation Rate on Rodents and Treeshrews in Different Habitats in Western Sarawak, Borneo

Teo Sieu Zhien

A thesis submitted

In fulfillment of the requirements for the degree of Master of Science

(Parasitology)

Institute of Biodiversity and Environmental Conservation
UNIVERSITI MALAYSIA SARAWAK
2021

DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Malaysia Sarawak. Except where due acknowledgements have been made, the work is that of the author alone. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

……

Signature

Name: Teo Sieu Zhien

Matric No.: 16020063

Institute of Biodiversity and Environmental Conservation

Universiti Malaysia Sarawak

Date : 18/08/2021

ACKNOWLEDGEMENT

I would like to express my deepest gratitude to both of my supervisors, Professor Dr. Andrew Alek Tuen and Dr. Chong Yee Ling for their support, guidance, encouragement, and advice.

I also would like to sincerely acknowledge Mr. Isa Sait, Mr. Mohammad Hasri Al-Hafiz bin Haba, Ms. Rahah binti Mohamad Yakup, Mr. Lee Yang, Mr. Tan Jin Kiet, and Ms. Wong Sing Lien for their assistance during trappings. Furthermore, I thanked the residents in both urban housing areas and villages who gave full co-operation and help in trapping rodents and treeshrews for this study. Special thanks to the head and person-in-charge of all the villages included in this study. I also thanked both SALCRA and FELCRA oil palm estates for giving the permission to trap in their plantations and Sarawak Forest Department for research permit [Permit No. (287)JHS/NCCD/600-7/2/107 and park permit no. WL141/2018]. This study was funded by research grants [MPOB/02/2016(IA010200-0706-0003) and MPOB/04/2016] awarded to Professor Dr. Andrew Alek Tuen. Thanks a lot to Institute of Biodiversity and Environmental Conservation (IBEC) and Centre for Graduate Studies (CGS) for the advice and support given during my period of study in Universiti Malaysia Sarawak (UNIMAS).

A huge thanks to my lovely cousin, Ms. Sim Boon Hia for the map drawing; also my friends, Ms. Pang Sing Tyan, Ms. Julia Nelson, Ms. Stephanie Judi, Ms. Nurqamareena Karim for their help and advice throughout my journey of completing thesis. Moreover, thank you, Mum, Dad and my sister for being so supportive. They are one of the reasons I still carry on until today. And thank God. Without You, I can't make it this far.

ABSTRACT

Anthropogenic activities have created many new potential habitats for wildlife, which in turn may have implications on the diversity of small mammals as well as on their ectoparasite diversity and infestation rate. The objectives of this study are (i) to determine species richness and abundance of rodents and treeshrews in four selected different habitats, and (ii) to determine the ectoparasite diversity and infestation rate on rodents and treeshrews occupying these habitats. Seven forests, four oil palm plantations, six villages and six urban sites in western Sarawak, Borneo were sampled in this study. A total of 239 individuals comprising six species of rats, four species each of squirrels and treeshrews were captured by using baited cage trap technique. Both village and the urban area had comparably higher trapping success at 5.4% and 5.8% respectively compared to the forest which was lowest at 2.9%. Forest had the highest number of species (13), followed by oil palm plantation (7 species) and village and urban area with 4 and 3 species, respectively. Forests were dominated by *Sundamys muelleri* whereas *Rattus tanezumi* favored oil palm plantations, villages, and urban areas. The ectoparasites hosted on the trapped rodents and treeshrews were dislodged using combing technique and collected using forceps. A total of 11,684 individuals comprising 24 species of ectoparasites were recovered in this study. Twenty one species of ectoparasites were recovered from forests, 16 species from villages, 14 from urban areas, and 13 from oil palm plantations. The two dominant species (*S. muelleri* and *R. tanezumi*) were parasitized by multiple species of ectoparasites and with high parasite load for *Laelaps* spp., Chigger spp., and *Listrophoroides* sp. The highest infestation rate of ectoparasites (417 ectoparasite count) was recorded on an individual of *R. tanezumi* in Kampung Kuap, Samarahan; while the most number of ectoparasite species (eight species) was recorded on an individual of *S. muelleri* in Kampung Kuap, Samarahan

as well. In conclusion all treeshrew species and some squirrel species are absent in villages and urban areas while rats such as *R. tanezumi* and *S. muelleri* are dominant in villages and urban areas. The habitat has a greater influence on the ectoparasite diversity and infestation rate of rodents and treeshrews, compared to animal effect. The high density and infestation rates of rats in villages and urban areas may increase people's exposure to rodent-borne ectoparasites and this may raise the risk to public health.

Keywords: Small mammals, forest, oil palm plantation, village, urban

Kepelbagaian dan Kadar Infestasi Ektoparasit pada Roden dan "Treeshrew" di Habitat Berlainan di Barat Sarawak, Borneo

ABSTRAK

Kegiatan antropogenik telah mewujudkan banyak habitat baru untuk hidupan liar, di mana terjadi implikasi terhadap kepelbagaian mamalia kecil serta terhadap kepelbagaian dan kadar infestasi ektoparasit mamalia kecil tersebut. Objektif kajian ini adalah (i) untuk menentukan kekayaan dan kelimpahan spesies roden dan "treeshrew"di empat habitat berlainan yang dipilih, dan (ii) untuk menentukan kepelbagaian dan kadar infestasi ektoparasit pada roden dan "treeshrew" yang mendiami habitat-habitat tersebut. Tujuh hutan, empat ladang kelapa sawit, enam kampung dan enam bandar di Barat Sarawak, Borneo telah disampelkan dalam kajian ini. Sejumlah 239 individu yang terdiri daripada enam spesies tikus, empat spesies tupai dan "treeshrew" masing-masing telah ditangkap dengan menggunakan teknik perangkap sangkar dengan umpan. Kedua-dua kampung dan bandar mempunyai tahap kejayaan perangkap yang lebih tinggi iaitu 5.4% dan 5.8%, sementara hutan mempunyai tahap kejayaan terendah pada 2.9%. Hutan mempunyai jumlah spesies yang tertinggi (13), diikuti oleh ladang kelapa sawit (7 spesies) dan kampung serta bandar dengan masing-masing 4 dan 3 spesies. Hutan didominasikan oleh Sundamys muelleri *sedangkan* Rattus tanezumi *lebih menyukai kawasan ladang kelapa sawit, kampung, dan bandar. Ektoparasit yang hidup pada roden dan "treeshrew" yang ditangkap telah digugurkan menggunakan teknik menyisir dan dikutip menggunakan forsep. Sebanyak 11,684 individu yang terdiri daripada 24 spesies ektoparasit telah dikumpul dalam kajian ini. Hutan merekodkan 21 spesies ektoparasit, diikuti oleh kampung (16 spesies), bandar (14 spesies), dan ladang sawit (13 spesies). Dua spesies dominan (*S. muelleri *dan* R. tanezumi*) didiami oleh pelbagai spesies ektoparasit dan*

dengan bilangan parasit yang tinggi, khususnya spesies Laelaps*, spesies Chigger, dan spesies* Listrophoroides*. Kadar infestasi ektoparasit tertinggi (417 jumlah ektoparasit) dicatatkan pada seekor* R. tanezumi *di Kampung Kuap, Samarahan; sementara jumlah spesies ektoparasit terbanyak (lapan spesies) dicatatkan pada seekor* S. muelleri *di Kampung Kuap, Samarahan juga. Kesimpulannya semua spesies "treeshrew" dan beberapa spesies tupai tidak ditemui di kampung dan kawasan bandar manakala tikus-tikus seperti* R. tanezumi *dan* S. muelleri *mendominasi kampung dan kawasan bandar. Habitat lebih banyak mempengaruhi kepelbagaian ektoparasit dan kadar infestasi tikus dan "treeshrew", berbanding dengan kesan haiwan. Kepadatan dan kadar infestasi tikus yang tinggi di kampung dan kawasan bandar dapat meningkatkan pendedahan orang ramai terhadap ektoparasit bawaan tikus dan ini boleh mendatangkan risiko kesihatan awam.*

Kata kunci: *Mamalia kecil, hutan, ladang kelapa sawit, kampung, bandar*

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

%	Percentage
<	Less than or smaller than
>	More than or greater than
µm	Micrometre
CGS	Centre for Graduate Studies
cm	Centimetre
DNA	Deoxyribonucleic acid
e.g	Example
etc.	Et cetera
FELCRA	Federal Land Consolidation and Rehabilitation Authority
g	Gram
GPS	Global Positioning System
ha	Hectares
i.e.	That is
IADP	Integrated Agricultural Development Project
IUCN	International Union for Conservation of Nature
km^2	Kilometre square
Kpg.	Kampung
m	Meters
m^2	Meter square
Mha	Mega hectares
MPOB	Malaysian Palm Oil Board
RM	Ringgit Malaysia
SALCRA	Sarawak Land Consolidation and Rehabilitation Authority
sp./spp.	Species

Tg.	Tanjung
UNIMAS	Universiti Malaysia Sarawak
WHO	World Health Organization
WLPO	Wild Life Protection Ordinance

CHAPTER 1

GENERAL INTRODUCTION

1.1 Study Background

Sarawak is located in Borneo, the third-largest island in the world which houses mega diversity of flora and fauna (Myers et al., 2000). It is richly endowed with different natural habitats, such as primary lowland, montane forests, peat swamp forests, kerangas forests, mangrove forests, and limestone forests (MacKinnon et al., 1996). To meet the need of increasing population and the government's agenda for socio-economic development, these forest habitats have been lost or degraded through logging (approximately 3.89 million ha had been logged in 2010 since 1973) and agricultural activities (approximately 2.30 million ha) (Bryan et al., 2013; Gaveau et al., 2014; Hussin, 2019). As of 2010, only 3% of Sarawak land was covered by undisturbed and primary forests under protected area (Bryan et al., 2013). Other anthropogenic activities, such as urbanization and infrastructure development also led to the loss of forests and ecosystem services (Brook et al., 2003).

Loss of forests caused the decline of forest-dependent small mammal (rodents and treeshrews) species (Turner, 1996). Whereas other more flexible and adaptable small mammal species would invade newly created habitats for survival (Dickman & Doncaster, 1989; Ewers & Didham, 2006). When these small mammals moved from their natural habitats to human-modified habitats, such as urban area, it may affect the survival of their rodent-associated ectoparasites (Maaz et al., 2018). Some non-host specific ectoparasites (ticks, fleas and chiggers) decreased in their number when their host animals moved to more urbanised or more disturbed habitat (Maaz et al., 2018). Contrastingly, those

ectoparasites which are highly dependent to their host appeared to be more abundant in urbanised areas (Maaz et al., 2018). Different types of rodent-associated ectoparasites can either depend on its host for survival (for example, lice) or spend more time in their host's nest (for example, fleas) (Johnson et al., 2004; Light et al., 2010; Maaz et al., 2018). Therefore, the species diversity and abundance of ectoparasites on rodents and treeshrews are strongly depended on the (i) host species and/ or (ii) the trapping habitat (Maaz et al., 2018).

1.2 Significance of the Study and Research Hypothesis

Previous studies on rodents and treeshrews have focused on the effect of habitat conversion on their diversity and conservation (Bernard et al., 2009; Wells et al., 2014), nutrient partitioning (Christe et al., 1996; Tamerat et al., 2016), medical and veterinary concerns regarding parasite infestation rate of these animals (Himsworth et al., 2013; Meerburg, Singleton, & Kijlstra, 2009), and diversity of ectoparasites on host from different habitats (Chuluun et al., 2005; Madinah et al., 2013; Paramasvaran et al., 2009). None of these researches has been conducted in western Sarawak. The data on arthropod ectoparasites recovered from rodents and treeshrews trapped in different types of habitats in western Sarawak can provide insight on the potential transmission of zoonotic disease.

It is hypothesised that the species diversity of rodents and treeshrews would decrease in highly disturbed habitat such as oil palm plantation, village and urban area resulting in a change in species composition and relative abundance. As a consequence of this change, the species composition and abundance of their ectoparasites will also differ among the habitats studied.

1.3 Aim of the Study

The aims of this study are (i) to determine species richness and abundance of rodents and treeshrews in forests, oil palm plantations, villages and urban areas, and (ii) to determine ectoparasite diversity and infestation rates on rodents and treeshrews occupying these habitats.

1.4 Thesis Outline

This chapter (Chapter 1) gives a brief introduction to this research, whereas Chapter 2 presents the review of literature related to this study. Chapter 3 and Chapter 4 present the findings of rodents and treeshrews and their ectoparasites, respectively. Chapter 5 discusses on overall result and concludes this study with some recommendations for future related studies.

CHAPTER 2

LITERATURE REVIEW

2.1 Habitat Conversion in Borneo

The island of Borneo is the third-largest island (around 737188 km^2) in the world, and it is one of its "biodiversity hotspots" (Gaveau et al., 2014; Myers et al., 2000). Borneo hosted various types of natural habitats for wildlife from the coastal to the interior part of the land, from low altitude to high altitude. These natural habitats included beach forest, mangrove forest, freshwater, and peat swamp forest, kerangas forest, lowland dipterocarp forests, hill and montane forests (around 1700 m to 2700 m above sea level) (Aiba & Kitayama, 1999; MacKinnon et al., 1996; Payne et al., 1985).

Natural calamities such as landslides have been impacting these habitats before the arrival of mankind (Abere & Opara, 2012). Human activities which are varied and extensive are the major factor that causes forest loss, fragmentation, and degradation (Gaveau et al., 2014, 2019). These activities include shifting cultivation, commercial logging, agriculture plantation, human recreation, and rural ecotourism, and development of new human settlements and townships (Bryan et al., 2013; Charles & Ang, 2010; Curran et al., 2004; Gaveau et al., 2014; Lo et al., 2012; Phua et al., 2014; Schlacher & Thompson, 2012; Wells et al., 2014). The habitats in the context of this study are hereby defined as in Table 2.1. Satellite imagery studies showed that between 2000 – 2017, Borneo suffered a loss in forest area by 14% (6.04 Mha), while plantations expanded by 170% (6.20 Mha: 88% oil palm; 12% pulpwood) (Gaveau et al., 2019).

Table 2.1: Brief description of different land use in this study.

Type of land use	Description
Primary forest	Abundance of emergent trees; no clearly visible indications of human activities.
Secondary forest	No emergent tree, trees are not tall.
Agroforest	Close to human settlements; forest with many planted fruit trees.
Lowland forest	Forest located below 500 meters above sea level (asl).
Limestone forest	Forest located on hard limestone hill with visible caves.
Peat swamp forest	Moist and flooding forest with thorny plants.
Peat soil plantation	Oil palm plantation established on peat soil, which is moist and with poor drainage system.
Mineral soil plantation	Oil palm plantation established on mineral soil, which is dry and hard if there is no rain.
Village	Dense clustering of residential houses, often surrounded with agroforest and shrubs; no tall buildings.
Urban	Dense clustering, mostly built-up area with residential and shop houses; some may have bushes or small forest patches next to the houses; tall buildings and heavy traffic.

2.1.1 Shifting Cultivation

Shifting cultivation was mostly practiced by the ethnic groups which lived in rural areas, such as the Iban tribe in Sarawak, Borneo (Mertz et al., 2009). The Iban farmers burned and cleared the primary forest, then planted crops, such as rice, maize, and vegetables (Ichikawa, 2010). In western Sarawak, the Bidayuh tribe have impacted land similarly to the Iban. Cropping continued until the productivity of the land was reduced and then new land will be opened up again. The previous cropland was allowed to grow into secondary forest or agro-forest (Padoch, 1982). This form of cultivation that was practiced for generations in olden days was largely sustainable. However, the practice and area under shifting cultivation in Sarawak had since declined (Ichikawa, 2007; Mertz et al.,

2009) due to the availability and convenience of buying ready-stock of rice, fresh vegetables and other crops from the market (Ichikawa, 2007). The decline in shifting cultivation is also linked to exodus of young men and women from their rural communities to towns and cities for paid non-farming jobs (Ichikawa, 2007).

2.1.2 Commercial Logging

Commercial logging or timber extraction has greatly impacted the intact forests (Gaveau et al., 2014). It is estimated that 80% of the land surface of Sabah and Sarawak was impacted by previously undocumented, high-impact logging or clearing operations from 1990 to 2009 (Figure 2.1) (Bryan et al., 2013). As of 2010, approximately 3.89 million ha (23% of forest in Sarawak) was logged (Gaveau et al., 2014). Commercial logging started in lowlands and peatlands in 1960s (Aiken & Leigh, 1992) but have expanded into the hilly and mountainous interior since 1980s (Gaveau et al., 2014; Miettinen et al., 2011). Unsustainable logging practice such as not following the recommended re-entry cycle, dense logging roads and use of bulldozers damaged the soil, waterways, and forest structure, thus causing longer period of time for regeneration of timber stocks (> 30 years) (Pinard & Putz, 1996; Putz et al., 2008; Sist et al., 2003). Commercial logging of natural forest is now a dying industry, and as timber resource dwindled the State government is thinking to ban export of log (The Star, 2019).

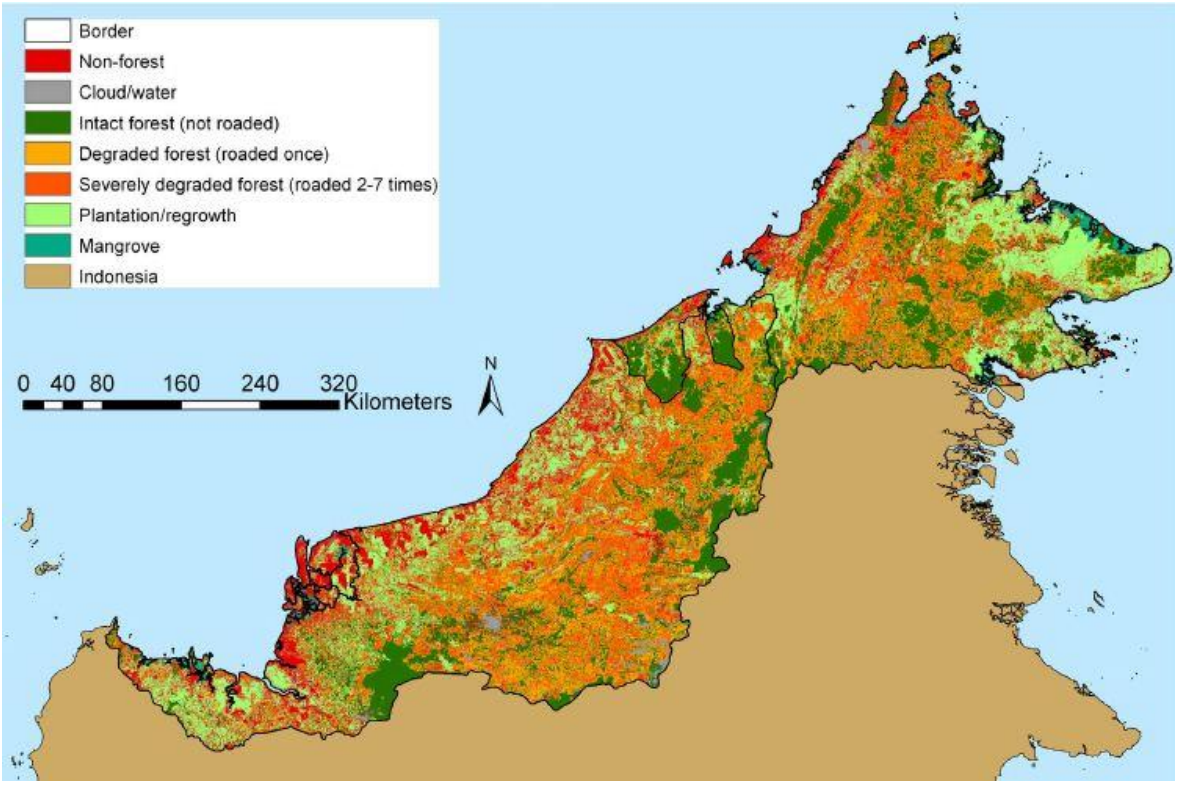

Figure 2.1: Condition of forest in Borneo in 2009. (Source: Bryan et al., 2013).

2.1.3 Agriculture Plantation

In early 1880s, pockets of forests in Sarawak, were cleared for rubber plantation (Aiken & Leigh, 1992). Then in 1970s, oil palm industry was introduced to Sarawak, and huge area was slowly converted into oil palm plantations (Hon & Shibata, 2013). Oil palm plantations were initially established on mineral soil; and later as suitable lowland mineral soils became scarce, and peat technology and knowledge on water management improved, peat land development intensified. Peat swamp-to-palm conversion scheme (i.e. Samarahan Integrated Agricultural Development Project, IADP) was being implemented in Samarahan division, Sarawak (Figure 2.2), in which peatlands were being converted first into coconut, and then into oil palm estates (Phillips, 1998). As at December 2019, 1.58